PSYCHOLOGICAL AND PHYSIOLOGICAL EFFECTS OF WEARING A GAS MASK OR PROTECTIVE SUIT UNDER NON EXERCISING CONDITIONS

D. H. RYMAN

NAVY AIR FORCE ARMY
JWGD³
MILPERF

REPORT NO. 88-11

NAVAL HEALTH RESEARCH CENTER
P.O. BOX 85122
SAN DIEGO, CALIFORNIA 92138

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND
BETHESDA, MARYLAND

PSYCHOLOGICAL AND PHYSIOLOGICAL EFFECTS OF WEARING A GAS MASK OR PROTECTIVE SUIT UNDER NON EXERCISING CONDITIONS

D. H. Ryman

T. L. Kelly

C. E. Englund

P. Naitoh

M. Sinclair

Naval Health Research Center

P. O. Box 85122

San Diego, California 92138-9174

Report No. 88-11, supported by the Naval Medical Research and Development Command, Department of the Navy, under Work Unit 2M463764B995.AB087-6. The views presented in this paper are those of the authors and do not reflect the official policy or position of the Department of the Navy, the Department of Defense, or the U. S. Government. The authors wish to thank the members of the U. S. Marine Corps First Division who served as volunteer subjects for the studies described in this article. Portions of this data have been previously presented (Ryman, Englund, Kelly and Naitoh, 1987).

SUMMARY

Two studies investigated the psychological and physiological effects of the M17A2 gas mask (Study 1) and MOPP IV (Mission Oriented Protective Posture level 4 gear) chemical protective suit (Study 2). Both studies used the same psychological scales: the Profile of Mood States (POMS) Vigor and Fatigue scales, the School of Aerospace Medicine Subjective Fatigue Checklist (SAM FATIGUE), The Kogi Symptom checklist (SYMPTOMS), the Naval Health Research Center's Positive and Negative mood scales (POSITIVE MOOD and NEGATIVE MOOD), and the Stanford Sleepiness scale (SLEEPINESS). The physiological measures included heart rate, core temperature, blood pressure and grip strength.

In Study 1, 16 pairs of subjects were tested over two 4-hour periods, one with the mask and one without. In the second study 12 pairs of subjects were tested over two 12-hour periods with and without MOPP gear. Both studies used a counterbalanced order: a randomly selected subject from each pair wore the mask or MOPP gear the first day while the other subject wore it the second.

Increases in SYMPTOMS, with borderline increases in SAM FATIGUE and heart rate, and diastolic blood pressure were seen in the mask condition. The change in heart rate proved only to be significant among the female subjects. In the MOPP condition there were increases in heart rate, temperature, and all measures of negative states (POMS FATIGUE, SAM FATIGUE, SLEEPINESS, SYMPTOMS, and NEGATIVE MOOD), with decreases in the positive measures (VIGOR and POSITIVE MOOD) and grip strength. All of the changes seen in MOPP were significant for the first 4-hours. All measures except core temperature, grip strength, and POSITIVE MOOD showed MOPP effects in the first hour of testing.

The increase in SLEEPINESS seen with the MOPP gear correlated significantly with the increase in core temperature. There were no other physiology-psychology relationships. There was no correlation between the amount of change in any measure when the mask or MOPP gear was worn and the amount of previous experience the subject had with that gear.

Overall, the changes observed, though significant, were not much different from those observed over two sustained 20 hr days for non-exercising subjects (Naitoh, Englund and Ryman, 1983, 1984). Also the psychological and physiological changes in the MOPP suit were not to a degree to indicate that wearing this gear for 12 hrs without exercise would seriously degrade performance.

INTRODUCTION

Gas masks and protective suits can have deleterious psychological effects on the wearer, such as panic, confusion (Brooks, Xenakis, Ebner and Balson, 1983), shortness of breath, and claustrophobia (Carter and Cammermeyer, May 1985). In his review of this area Morgan (1983) pointed out that these topics had been addressed in only a very cursory manner and that there had been little systematic research into these effects. The present studies examined the effects of wearing (1) the M17A2 gas mask and (2) full chemical protective (Mission Oriented Protective Posture level 4-MOPP IV) gear, both studies under non-exercise, sedentary conditions. Standardized psychological tests were used as measures of mood, symptoms, fatigue, and sleepiness. Vital signs (heart rate, blood pressure, and core temperature) and grip strength were also collected hourly. This report covers these two studies. All subjects were volunteer U. S. Marine Corps personnel.

METHODS

Study One

In the first study (Mask study) 32 subjects (24 males and 8 females, characteristics summarized in Table 1) were given a series of psychological and reaction time tasks presented by computer over two 4-hour periods (sessions 1-4). Heart rate, core temperature, blood pressures and grip strengths were also recorded hourly. Subjects were tested in pairs. Half the pairs were tested in the morning (0730 to 1130) and half in the afternoon (1300 to 1700). One of each pair was randomly assigned to be tested the first day while wearing the M17A2 mask (Kelly, Yeager, Sucec, Englund, and Smith, 1987) and the second day without, while the other subject did the reverse.

The masks had been modified to allow measurement of volumes, rates of flows and composition of expired air. The modification entailed replacement of the outlet valve with a brass tube fitted with a one-way valve with resistance similar to the unaltered mask (Kelly, et al., 1987). The masks were checked for fit and leaks at the start of the 4 hour testing sessions. In the mask condition subjects were required to wear the mask for the

entire 4 hour testing period. Subjects were allowed as much water as they desired (the M17A2 has an attachment allowing drinking from a canteen without the removal of the mask).

Table 1 - Subject Characteristics

		MASK STUDY			
MALES	MEAN	SD	MIN	MAX	N*
AGE (YEARS)	24.7	4.4	18	34	24
YEARS SERVICE	5.4	3.9	1.0	15	24
PAY GRADE	4.4	1.1	3	7	23
PREVIOUS EXPERIENCE[a]	161.0	651.0	0	3000	21
LOG_{10} PREV. EXP.+1[b]	.93	.93	0.0	3.48	21
FEMALES	MEAN	SD	MIN	MAX	N*
AGE (YEARS))	21.0	3.8	18	29	7
YEARS SERVICE	2.3	3.4	0.5	10.0	7
PAY GRADE	3.0	1.4	2	6	7
PREVIOUS EXPERIENCE[a]	1.0	0.0	1.0	1.0	5
LOG_{10} PREV. EXP.[b]	.0	.0	.0	.0	5

MOPP STUDY	MEAN	SD	MIN	MAX	N*
AGE (YEARS)	23.1	3.5	18	29	24
YEARS SERVICE	4.2	3.1	0.5	2.0	24
PAY GRADE	3.8	1.1	2	6	24
PREVIOUS EXPERIENCE[a]	67.2	84.4	0	400	21
LOG_{10} PREV. EXP[b]	2.5	.7	0.0	2.6	21

N = number of subjects with data
SD = standard deviation
MIN = minimum value
MAX = maximum value
* Missing values were due to incomplete forms or uncodeable responses.
[a] Hours of previous experience using gas masks and/or MOPP gear. When the subject with 3000hrs is eliminated, the mean is 19.0, S.D.=26.1, max=100.
[b] LOG PREV. EXP.+1 = Log base 10 of the hours of previous experience using gas masks and/or MOPP gear. The constant 1 was added so that those with zero (0) hrs would have a value of zero after the log transformation. When the subject with 3000hrs is eliminated the mean is .80, S.D.=.74, max=2.0.

The psychological measures used were: the Profile of Mood States (POMS), which included scales of vigor and fatigue (POM VIGOR and POM FATIGUE); the School of Aerospace Medicine Subjective Fatigue Checklist (SAM FATIGUE); the Kogi Symptom Checklist (SYMPTOMS; the list of these 30 symptoms found to increase with work fatigue appears in Table 2); the Naval Health Research Center Mood questionnaire, which included a negative and a positive scale (NEGATIVE MOOD and POSITIVE MOOD); and the Stanford Sleepiness Scale (SLEEPINESS). The computer presentation of these measures has been reported in detail elsewhere (Ryman, Naitoh and Englund, 1984). Subjects had several hours of training in these questionnaires on the day preceding the first testing day. These tasks were administered once per hour, along with some reaction time tasks (data to be presented separately). Blood pressure, left and right grip strengths, and core temperature were checked once per hour. Heart rate was monitored for 20 minutes per hour (for the purposes of this study, the mean heart rate for each 20 minute period has been used).

Study Two

The second study (MOPP study) involved 24 male subjects (see Table 1), 6 who had participated in the first phase and 18 new subjects. This study used the same tasks in the same order and monitored the same physiological measures as Study 1. Testing started about 0730 and continued for 12 hours each testing day, with a 45 minute lunch break after 6 hours. The two testing days were separated by a non-testing day when subjects were free to do as they pleased as long as they did not drink alcohol and got adequate sleep.

Subjects in this study wore full MOPP gear rather than just the mask. The MOPP gear consisted of a two piece charcoal impregnated canvas suit, the M17A2 gas mask, a hood that fitted over the mask, butyl rubber gloves, and rubber boot covers, all worn over standard fatigues and army boots (Kelly, et al., 1987). The No-MOPP subjects wore fatigues and boots. MOPP subjects were required to keep the gear intact for the entire 12 hour period except for 45 minutes at lunch, when they were allowed to remove the mask, hood, and gloves. There were occasional brief periods where the jacket or suit had to be unzipped (e.g. adjustment of the heart rate telemetry device). The masks were tested for fit and leaks at the start of the day and after

Table 2: Kogi Symptom Scale

SYMPTOM	MASK MEAN	NO MASK MEAN	MOPP MEAN	NO MOPP MEAN
Head feeling heavy	.28	.10	.34	.07
Whole body getting tired	.20	.13	.34	.03
Legs feeling heavy	.05	.05	.17	.01
Yawning	.43	.25	.38	.19
Muddled brain	.09	.08	.29	.05
Becoming drowsy	.40	.26	.50	.18
Eye strain	.31	.22	.48	.18
Rigid or clumsy in motion	.06	.04	.25	.01
Unsteady in standing	.05	.02	.15	.02
Want to lie down	.26	.19	.35	.12
Difficulty in thinking	.06	.06	.23	.01
Weary of talking	.05	.06	.12	.01
Becoming irritable	.17	.10	.34	.07
Unable to concentrate attention	.13	.09	.28	.09
Unable to have interest	.11	.10	.24	.09
Apt to forget things	.17	.14	.15	.06
Apt to make mistakes	.27	.24	.26	.10
Uneasy about things	.11	.14	.17	.03
Unable to straighten up	.10	.06	.16	.02
No energy	.13	.06	.20	.05
Headache	.35	.09	.43	.03
Stiffness in shoulders	.21	.09	.25	.03
Low back pain	.09	.05	.17	.07
Breathing oppressed	.21	.03	.26	.01
Thirsty	.40	.31	.31	.20
Husky voice	.03	.04	.06	.01
Dizziness	.05	.04	.12	.02
Eyelids twitching	.08	.09	.10	.03
Tremor in limbs	.02	.02	.06	.01
Feeling unwell	.16	.10	.20	.01
Total	5.04	3.24	7.31	1.80

All symptom means were based on the response scale 0 = No 1 = Yes. These means when multiplied by 100 equal the average percent responding yes in each condition.

MEAN = The mean of subjects reporting that symptom over the 12 MOPP (N=24) sessions or the 4 MASK sessions (N=32). The Total is the sum of the means of all symptoms reported under each condition.

the lunch break. Water was available ad lib and was taken without the removal of the mask during the experiment through the tube-connector valve in the mask.

Analysis

Mask vs No-Mask and MOPP vs No-MOPP comparisons were tested by paired (correlated) t-tests. Changes over time (sessions), experimental and possible confounding effects (AM vs PM start and condition order) as well as interactive effects were examined by multivariate analysis of variance (MANOVA; Norusis, 1985). The conservative Bonferroni significance levels (Harris, 1976) for multiple significance testing were used to correct for multiple significance testing on correlated variables. In this method the standard level for significance ($p=.05$) is adjusted by dividing by the number of measures. For example when the results of the seven psychological scales were being analyzed for mask or MOPP effects, $p=.007$ (.05/7-scales) was used instead of $p=.05$. Similarly, when five physiological measures were analyzed, $p=.01$ (.05/5 measures) was set for significance. Variables showing significance levels of .05 are reported in the text but only those reaching the conservative levels were considered significant.

Relationships between the psychological and physiological effects, and between these effects and other non-experimental factors, such as age, years service and the amount of previous experience with the gear, were calculated using Pearson product moment correlation coefficient. Significant linear relationships were said to exist when Pearson correlation coefficients (r_p) were confirmed by Spearman correlation coefficients (r_s) which are less susceptible to the effects of outliers. Because the hours of experience with chemical defense gear had an extremely positive skew, a $\log_{10}$ transformation was done on this variable, with a constant of 1 added so that when 0 hours of experience occured a transformation was possible.

RESULTS

Study One

In the four hour Mask study only the increase in SYMPTOMS between Mask and No-Mask condition means reached the conservative ($p=.007$) level of

significance (see Table 3). More of these work related fatigue symptoms were reported by subjects in the mask than the unmasked condition (5.0 vs 3.2, t=3.27, p=.003). Minor fatigue symptoms were predominant (see Table 2). Masked subjects also showed greater FATIGUE by the SAM scale at the standard (p=.05) non-corrected level of significance (5.6 vs 4.8, t=2.59, p=.014). The SYMPTOMS and FATIGUE effects were present at standard level of significance within the first hour of wearing the mask (SYMPTOMS: mask 3.4 vs no-mask 2.6, p=.049; SAM FATIGUE: mask 5.4 vs no-mask 4.7, p=.014).

None of the physiological measures showed significant differences between the Mask and No-Mask period means at the conservative level of significance (p=.01). Heart Rate was the only physiological measure to show any mask effect at the standard (p=.05) level of significance.

The symptoms increased over the four sessions while heart rate and core temperature decreased over sessions (significant conservative p<.01 linear trends) with or without the mask (see Table 4 and Figures 1, 2, and 3). Subjects also reported small increases (p<.05) in fatigue symptoms from the first to last sessions. A MANOVA showed significance at the standard level for the interaction between sex and the mask effect on heart rate (F(1,21)= 5.25, p=.032). Because of this, separate heart rate t-tests were done in the male and female subgroups. This revealed that the increase in heart rate with the mask were only significant among the females (mask 78.4 vs no-mask 73.2 bpm, t=4.99, df=7, p=.002). MANOVA showed no sex effects on the other variables which showed mask effects.

Study Two

POM FATIGUE, SAM FATIGUE, NEGATIVE MOOD, SYMPTOMS, and SLEEPINESS (all the 'negative' psychological measures) showed higher scores for the 12 hrs in the suit than without, while POMS VIGOR and POSITIVE MOOD (the two measures of positive states) were lower (p<.007 for all). Subjects reported more symptoms (see Table 2), more sleepiness, less positive mood, etc., when they were tested in MOPP gear (see Table 3). Additionally, all the physiological measures except blood pressure had significant 12 hr mean differences. There were increases in heart rate and core temperature and a decreased grip strength in the MOPP condition (p<.001 for all).

NUMBER OF SYMPTOMS BY SESSIONS FOR TWO STUDIES

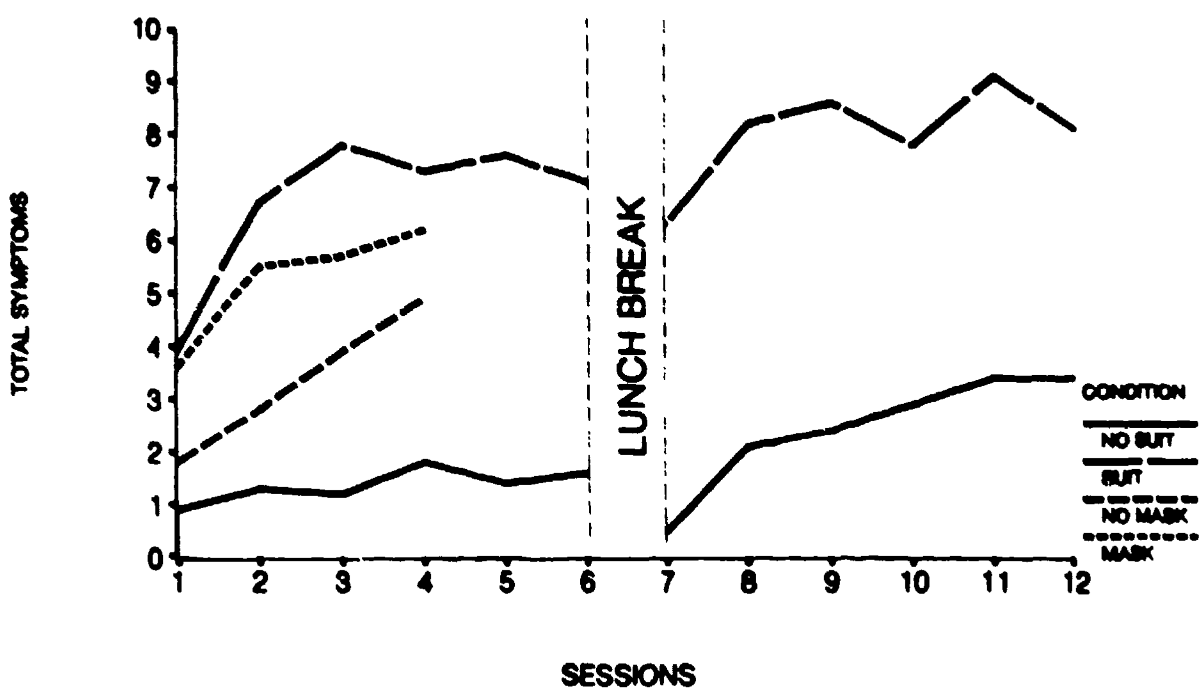

FIGURE 1. KOGI SYMPTOMS SESSION MEANS
MASK, NO MASK AND MOPP, NO MOPP CONDITIONS

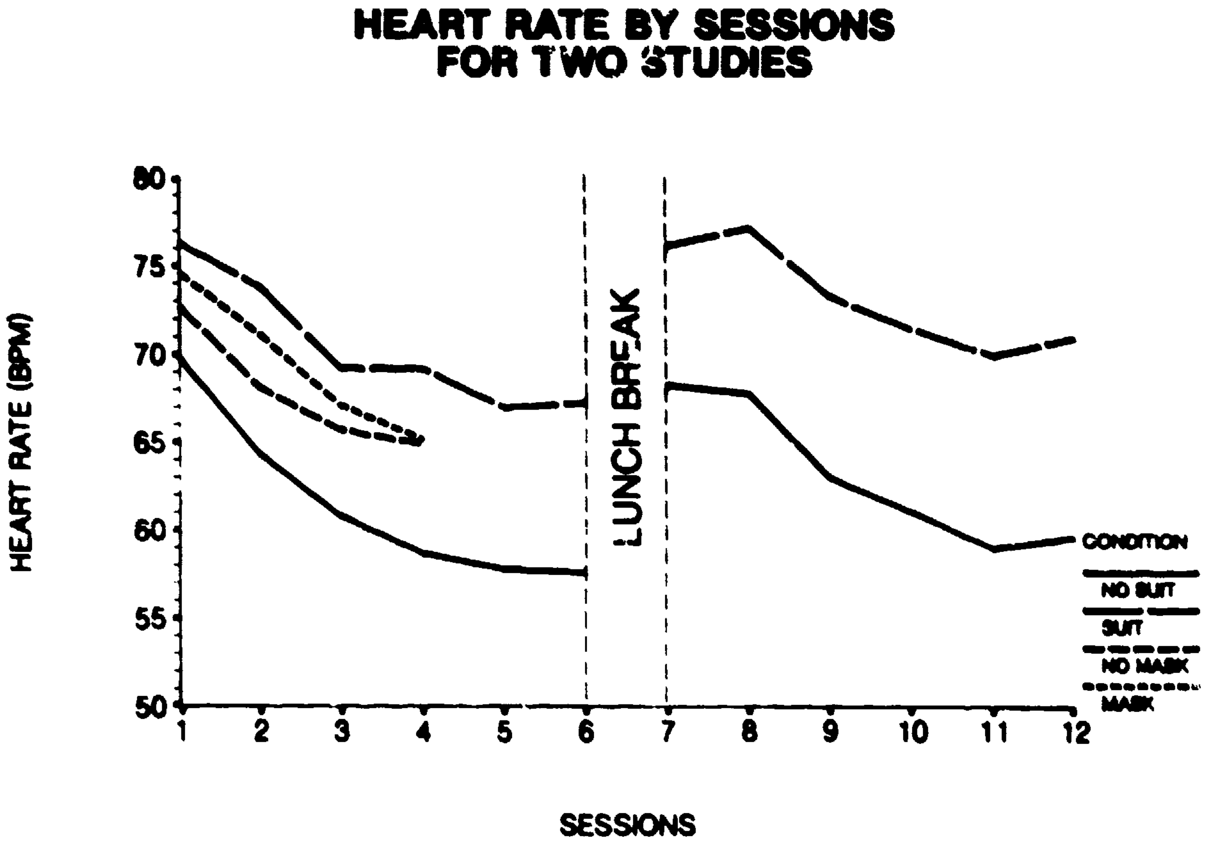

FIGURE 2. HEART RATE SESSION MEANS
MASK, NO MASK AND MOPP, NO MOPP CONDITIONS

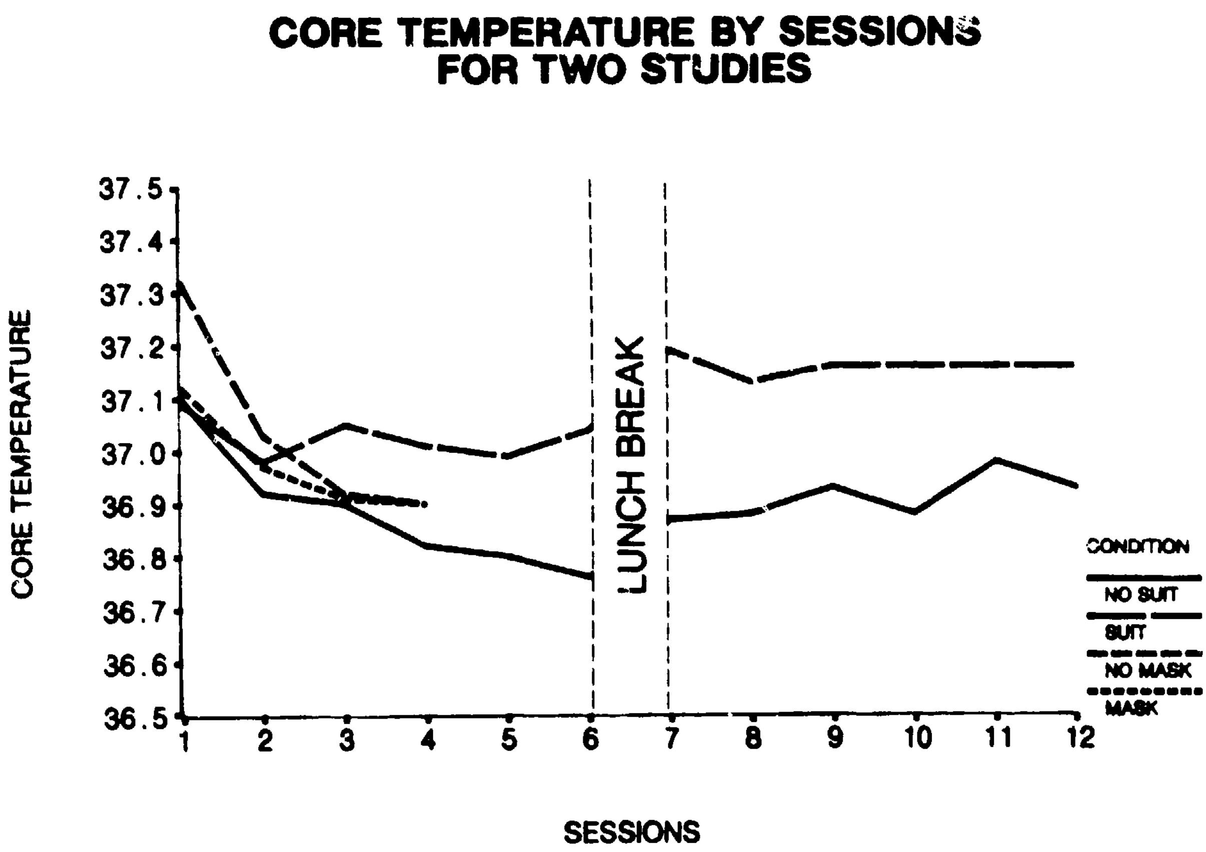

FIGURE 3. CORE TEMPERATURE SESSION MEANS
MASK, NO MASK AND MOPP, NO MOPP CONDITIONS

Table 3. Mask no-mask and MOPP no-MOPP means, standard deviations (SD), and t values for psychological and physiological measures

PSYCHOLOGICAL MEASURE	SCALE	MASK MEAN	MASK SD	NO MASK MEAN	NO MASK SD	t	p*	df
POMS	Vigor	17.2	7.5	17.7	6.9	-.48	.636	31
POMS	Fatigue	3.6	3.9	3.1	3.6	.85	.404	31
SAM	Fatigue	5.6	2.0	4.8	1.9	2.59	.014	31
Kogi	Symptoms	5.0	5.0	3.2	3.7	3.27	.003	31
NHRC	Negative	4.2	4.3	4.0	4.1	.46	.647	31
NHRC	Positive	38.0	11.7	38.4	11.4	-.31	.755	31
Stanford	Sleepiness	2.6	1.0	2.5	1.0	.38	.704	31

PHYSIOLOGICAL MEASURE	SCALE	MASK MEAN	MASK SD	NO-MASK MEAN	NO-MASK SD	t	p*	df
Heart Rate	BPM	69.5	9.9	67.8	9.1	2.07	.048	28[a]
Temperature	Centigrade	36.9	.2	37.0	.3	-1.54	.135	30[b]
BP - SYS	MM Hg	114.3	8.9	113.9	8.9	.37	.714	31
BP - DIAS	MM Hg	73.5	6.6	71.6	7.1	1.98	.056	31
Grip	Kg	45.9	12.7	45.4	12.9	.83	.415	31

PSYCHOLOGICAL MEASURE	SCALE	MOPP MEAN	MOPP SD	NO-MOPP MEAN	NO-MOPP SD	t	p*	df
POMS	Vigor	12.9	5.8	16.9	5.7	-4.89	<.001	23
POMS	Fatigue	4.8	5.1	1.4	2.1	3.86	.001	23
SAM	Fatigue	6.1	1.8	5.2	1.7	3.02	.006	23
Kogi	Symptoms	7.3	7.5	1.8	2.5	4.50	<.001	23
NHRC	Negative	5.9	4.3	2.6	2.1	4.80	<.001	23
NHRC	Positive	32.1	12.0	37.3	10.5	-3.58	.002	23
Stanford	Sleepiness	3.1	1.1	2.1	0.7	4.69	<.001	23

PHYSIOLOGICAL MEASURE	SCALE	MOPP MEAN	MOPP SD	NO-MOPP MEAN	NO-MOPP SD	t	p*	df
Heart Rate	BPM	71.8	8.8	62.3	6.6	7.79	<.001	23
Temperature	Centigrade	37.1	.20	36.9	.18	6.03	<.001	23
BP - SYS	MM Hg	116.7	11.0	116.9	7.6	-.18	.858	23
BP - DIAS	MM Hg	71.5	7.9	71.6	6.5	-.04	.970	23
Grip	Kg	47.5	8.5	52.7	9.0	-9.34	<.001	23

* Because of the multiple testing of correlated variables the conservative (Bonnferoni) level of significance was set at .007 for PSYCHOLOGICAL and .01 for PHYSIOLOGICAL measures.

[a] Data lost on 3 subjects because of equipment failure.

[b] One subject refused to use the rectal temperature probe.

BPM = beats per minute

SD = standard deviation

BP - SYS = systolic blood pressure

BP - DIAS = diastolic blood pressure

t = paired t-test of correlated means (Means of the 4 session for Mask and No Mask, and Means of the 12 Sessions for the MOPP and No MOPP).

Table 4: Significant sessions effects by MANOVA

	MEASURE	SCALE	F_{sess}	df	p	F_{lin}	df	p
STUDY 1								
	KOGI	Symptoms	3.22	3,20	.045	9.76	1,22	.005
	Temperature	Centigrade	13.19	3,25	<.001	26.58	1,27	<.001
	Heart rate	Beat/min	27.22	3,19	<.001	85.20	1,21	<.001
STUDY 2*								
	SAM	Fatigue	3.81	11,10	.022	4.68	1,20	.043
	POMS	Vigor	4.88	11,10	.009	21.37	1,20	<.001
	NHRC	Negative Mood	3.78	11,10	.023	6.54	1,20	.019
	Stanford	Sleepiness	3.70	11,10	.024	31.91	1,20	<.001
	Temperature	Centigrade	5.01	11,10	.008	+		
	Heart rate	Beat/min	8.69	11,10	<.001	+		

* The session differences and trend analysis results in study 2 reflect the pre-post lunch break changes (the mask and hood were removed during the 45 minute lunch); therefore, these findings should be interpreted with caution in regards to the effects of wearing this gear for 12hrs.

\+ Many significant trends were present on these measures, probably due to the injestion of food during the lunch break (see Figures 2 and 3).

Table 5: MOPP study four session mean values

PSYCHOLOGICAL		MOPP		NO-MOPP				
MEASURE	SCALE	MEAN	SD	MEAN	SD	t	p*	df
POMS	Vigor	14.5	6.3	18.2	6.0	-3.10	.005	23
POMS	Fatigue	4.4	5.2	1.2	1.9	3.76	.001	23
SAM Fatigue		6.0	1.9	5.1	1.9	3.38	.003	23
Kogi	Symptoms	6.5	7.0	1.3	2.0	3.94	.001	23
NHRC	Negative	5.7	4.9	2.2	1.9	4.10	<.001	23
NHRC	Positive	33.7	12.2	39.3	10.9	-2.82	.010	23
Stanford	Sleepiness	2.9	1.1	1.8	0.7	4.84	<.001	23
PHYSIOLOGICAL		**MOPP**		**NO-MOPP**				
MEASURE	SCALE	MEAN	SD	MEAN	SD	t	p*	df
Heart Rate	BPM	72.1	8.9	63.4	6.4	6.55	<.001	23
Temperature	Centigrade	37.0	0.2	36.9	0.2	1.97	.061	22+
Grip	Kg	47.4	8.2	51.3	8.7	-4.71	<.001	23

* Because of the multiple testing of correlated variables the conservative (Bonnferoni) level of significance was set at .007 for PSYCHOLOGICAL and .01 for PHYSIOLOGICAL measures.

\+ Temperature data was lost on one subject due to equipment failure.

When means of the first 4 hours for the MOPP and no MOPP conditions were analyzed, all of these effects remained significant at conservative levels

(p<.007) except for the decrease in POSITIVE MOOD where p was .010 (see Table 5). In the first hour, measurements of core temperature, grip strength, and POSITIVE MOOD did not differ in the MOPP condition as compared to No-MOPP. Subjects already showed increased SLEEPINESS and increased heart rates at the first hour of testing in MOPP gear ($p \leq .001$). NEGATIVE MOOD, POM VIGOR, both the POM FATIGUE and SAM FATIGUE, and SYMPTOMS showed effects at the standard (p.05) level of significance (see Table 6).

Several variables showed similar linear trends at the standard level of significance in the MOPP and No-MOPP conditions (see Table 4). VIGOR decreased over time (see Figure 4), and correspondingly SAM FATIGUE, NEGATIVE MOOD, and SLEEPINESS increased. There were slight recoveries in all of these measures from pre- to post-midday break period (see the changes between sessions 6 and 7, Figure 2). Heart rate showed a significant linear decrease between the start and the lunch break, and between post break and the end of the day, with an increase pre- to post-lunch (see Figure 3). The

Table 6: MOPP Study first session mean values

PSYCHOLOGICAL		MOPP		NO-MOPP			*	
MEASURE	SCALE	MEAN	SD	MEAN	SD	t	p	df
POMS	Vigor	16.3	7.1	19.6	6.7	-2.21	.038	23
POMS	Fatigue	3.3	4.9	1.5	2.2	2.18	.040	23
SAM	Fatigue	5.8	2.3	4.8	1.9	2.44	.023	23
Kogi	Symptoms	4.1	5.7	0.8	1.7	2.89	.008	23
NHRC	Negative	5.0	5.12	2.4	2.3	2.71	.013	23
NHRC	Positive	36.0	13.1	40.1	12.5	-1.65	.114	23
Stanford	Sleepiness	2.6	1.2	1.7	0.7	3.94	.001	23

PHYSIOLOGICAL		MOPP		NO-MOPP			*	
MEASURE	SCALE	MEAN	SD	MEAN	SD	t	p	df
Heart Rate	BPM	76.3	8.3	69.8	8.3	4.85	<.001	23
Temperature	Centigrade	37.1	.29	37.1	.38	-0.30	.766	21+
Grip	Kg	47.1	7.1	56.2	13.0	-1.90	.084	23

* Because of the multiple testing of correlated variables the conservative (Bonnferoni) level of significance was set at .007 for PSYCHOLOGICAL and .01 for PHYSIOLOGICAL measures.

\+ Temperature data was lost on two subjects during the first session due to equipment failure.

SD = standard deviation
df = degrees of freedom
BPM = beats per minute

POMS VIGOR SCALE BY SESSIONS
MOPP AND NO MOPP CONDITIONS

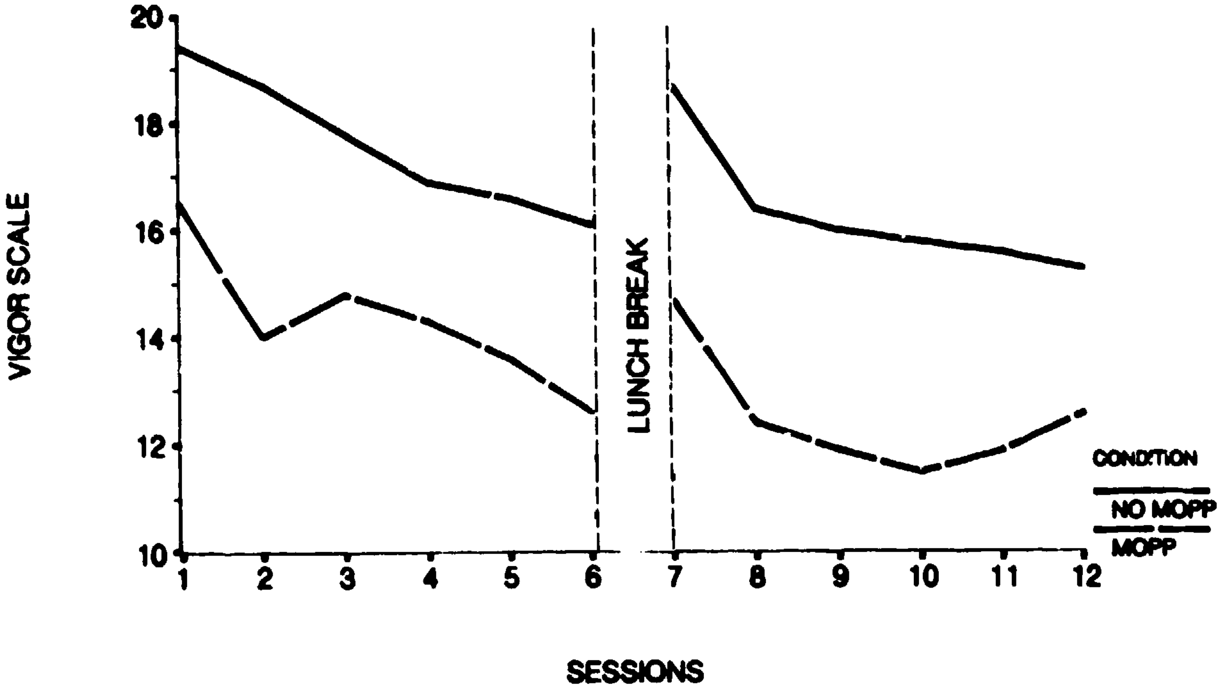

FIGURE 4. POMS, VIGOR SCALE SESSION MEANS
MOPP AND NO MOPP CONDITIONS

body temperature differed between the MOPP and No-MOPP conditions, though both conditions started out at the same temperature (session 1, Figure 3). The No-MOPP subjects showed a drop during the first six sessions, while the MOPP subjects maintained a more constant temperature. Temperature differences between MOPP and No MOPP reached a maximum by sessions 6 and 7. T-tests between the first session means and the means of the first four sessions did not show a significant difference between MOPP and no MOPP. No trends were observed in blood pressure or grip strength. There were no interactions or confounding effects demonstrated by MANOVA.

Mask vs MOPP Effects

The two studies were compared in unpaired t-tests (using the first four hours of the 12 hour days in the MOPP study). The MOPP condition had a greater heart rate ($p<.001$) and core temperature ($p<.01$) than the Mask. All psychological measures except SAM FATIGUE showed expected differences (higher negative and lower positive states) at the standard level of significance ($p<.05$).

Correlations

The amount of increase in SLEEPINESS when MOPP gear was worn (12 hr MOPP mean minus 12 hr No MOPP mean) correlated with the amount of increase in core temperature ($r_p=.579$, $p=.003$; $r_s=.549$, $p=.006$). There were no other physiology-psychology relationships that reached even the standard level of significance. Older subjects tended to report more symptoms in all conditions (no-mask, mask, no-MOPP, MOPP). The Pearson correlation coefficient (r_p) between age and number of symptoms reported was .404 ($p=.025$). This was confirmed by a Spearman's correlation coefficient (r_s) of .405 ($p=.050$). However, the amount of increase seen in SYMPTOMS when the mask or full MOPP gear was worn did not correlate with age (i.e. the difference between no-mask and mask or between no-MOPP and MOPP did not relate to age).

The amount of previous experience with protective gear, the number of years in the service, and the pay grade showed no significant correlation with mask or MOPP changes (Mask-no mask or MOPP-no MOPP) on any measure.

DISCUSSION

Study One

Gas masks and other respirators have been previously noted to have psychological effects (Morgan, 1983). Shephard (1962), discussing a British Service respirator, stated that most of the difficulties experienced by wearers were psychological reactions, including claustrophobia and distress from sweat accumulation on the face, rather than physiological responses.

Studies of psychological responses during simulated chemical warfare situations have found that the most severe responses appear related to the mask, rather than other aspects of protective gear. Brooks et al. (1983) reported that, out of 70 participants in a chemical warfare exercise, the 3 who were unable to complete the exercise experienced "panic immediately after donning the protective mask and manifested hyperventilation, shaking, confusion, fear of dying, and visual distortions." Carter and Cammermeyer (May 1985) found that the most frequent psychological responses reported by participants in a chemical defense exercise were rapid breathing, shortness of breath, and loss of side vision, all of which appeared predominantly mask related.

Using standard psychological tests in this non exercise condition, little evidence of psychological effects from wearing the M17A2 mask was found. There was a small increase in minor fatigue symptoms. There was also a non-significant increase in the SAM Fatigue scale. No other psychological measure showed a significant change. The Kogi symptom list does not specifically refer to feelings of claustrophobia, loss of side vision or rapid breathing as found by Carter and Cammermeyer (see above). Possibly such feelings were present or it may be that persons with a tendency to claustrophobia or anxiety responses are screened out in the admission process to the Marines, and/or are less likely to volunteer for a study involving masks. Field studies may also be more realistic than laboratory studies. There are clearly stresses other than the mask itself present in mock combat situations. These may serve to enhance or bring out otherwise undetectable mask effects.

Study Two

Psychological effects have been more widely reported with MOPP gear than with masks alone. Carter and Cammermeyer (1985) found that 69% of participants in a chemical defense exercise in which subjects wore MOPP gear reported some sort of psychological symptom. They note that this incidence of symptoms is much higher than that reported by Brooks et al. (1983), who used a similar scenario, and suggest that this might relate to the fact that the Brooks researchers only questioned those showing evidence of aberrant behavior while the Carter study solicited responses from all participants making it more analogous to our protocol.

Rauch, Bandaret, Tharion, Munro, Lussier and Shukitt (1986) found that perceptions of psychological rather than muscular fatigue were the primary factor correlating with sustained artillery performance in a simulated chemical warfare environment. Tharion, Rauch, Munro, Lussier, Banderet and Shukitt (1986) reported that, among subjects performing sustained armor operations in a simulated chemical warfare environment, "extreme symptom and mood changes resulted in medical casualties, combat ineffectiveness, and early termination of all testing". They noted that there were significant personality differences between those who experienced such problems and those who did not.

The present study showed clear evidence of psychological effects when full MOPP gear was worn. Every psychological measure showed slightly greater deterioration under the protective gear condition than for the mask alone. It appears that other aspects of the gear may have more effect than the mask, or alternatively, the stress of the additional gear may serve to uncover previously undetected mask effects, as the stress of the previously discussed field studies apparently did.

In earlier studies on Sustained Operations using the same computer presented scales similar changes were found in subjects not in MOPP gear who performed over 20 hours of sustained work with or without moderate exercise (Naitoh, Englund and Ryman, 1983; Naitoh, Englund and Ryman, 1984). Thus, MOPP gear may be a stress of similar degree to very prolonged work sessions. Future studies are in preparation to combine MOPP gear with sustained work

to determine how these factors interact. There were nc interactions between sessions effects and MOPP effects in the current study. However, 12 hours is relatively short for a sustained work session, and no sleep loss was involved.

Physiological Measurements

Study One

The lack of physiological effects when the M17A2 mask was worn alone was not unexpected. Even studies involving the additional stress of exercise have found that heart rate is either unchanged (Gee, Burton, Vassallo and Gregg 1968; Flook and Kelman, 1973; Stemler and Craig, 1977) or only slightly increased (Spioch, Kobza and Rump 1962; Hermansen, Vokax and Lereim 1972; Dukes-Dobos and Smith, 1984) by wearing a mask at matched workloads and exercise durations. Spioch et al. (1962) did report a significant increase in systolic blood pressure when a mask was worn during exercise. If heart rate at maximal exercise is measured, it tends to be lower with a mask, but lower levels of exercise are achieved (Shephard, 1962; Stemler and Craig, 1977; Lerman, Shefer, Epstein and Keren, 1983).

Only a few researchers have looked for physiologic effects from masks under non-exercise conditions. Shephard (1962) reported that supine resting subjects showed a small increase in systolic and diastolic blood pressure, with no change in cardiac output or pulse, when they breathed against moderate and large resistances. The resistances used (6.6 cm H_2O and 23 cm H_2O at 20 l/min flow) were higher than that present with our adapted mask (probably less than 1 cm H_2O, at 20 l/min), this study showed only a small near significant ($p=.053$) increase in diastolic blood pressure in the mask. Harber, Tamimie, Bhattacharya and Barber (1982) found a small but significant (2 beats per minute) increase in heart rate at rest with the addition of 4.9 cm H_2O/l/sec at 1 l/sec flow inspiratory resistance. Again, this is higher resistance than we used. Harber, Tammie, Bhatytacharya and Barber (1984) found no change in resting heart rate when a respirator cartridge of unspecified resistance was added to the inspiratory limb of the breathing circuit. Louhevaara, Tuomi, Korhonen and Jaakola (1984) found no change in resting heart rate when a conventional half mask (covering nose and mouth

but not eyes) with combined gas and dust filters (inspiratory resistance 4.5 cm H_2O, expiratory 2 cm H_2O at 2 l/sec flow) was worn.

Gas masks without other protective gear cover a minimal percent (about 2%) of the body's surface area and would be unlikely to significantly affect temperature regulation (Shephard, 1962). No previous reports on temperature effects of masks in resting subjects were found in a literature search. Dukes-Dobos and Smith (1984) found that neither a half nor a full facepiece air-purifying respirator affected oral temperature at high or low workloads under high or low heat conditions.

A number of studies have found decreased exercise endurance while wearing a mask (Van Huss, Hartman, Craig and Steinhaus, 1967; Craig, Blevins and Cummings, 1970; Craig, Blevins and Froehlich, 1971; Flook and Kelman, 1973; Stemler and Craig, 1977; Lerman et al., 1983). A literature search found no reports concerning mask effects on non-endurance type strength.

Masks clearly affect inspiratory and expiratory resistance and dead space. Kelly, Yeager, Sucec, Englund, and Smith (1987) previously found significant decreases in pulmonary function measures with the M17A2 mask. However, such effects are not pertinent at resting levels of breathing. So, the present study concurs with the general consensus in the literature that gas masks have little or no effect on resting physiology.

Study Two

Avellini (198_) evaluated several protective garments on exercising subjects at various levels of temperature and humidity. Under some conditions, heart rates were significantly higher in the suits than when a utility uniform was worn. Atterbom and Mossman (1978) found a 10% (8 bpm) increase in resting heart rate for subjects in a full body impervious suit. Goldman (1963) found that soldiers could wear either of two Chemical, Biological and Radiation (CBR) protective outfits in various environments (85°F with 75% relative humidity [RH], 95°F with 50% RH, or 105°F with 20% RH) for over four hours without exceeding a heart rate of 180 (the actual heart rates achieved were not given). The subjects in that study did not perform any activities. The 9.5 bpm (15%) increase in the mean heart rates

of our subjects corresponds very closely to the findings of Atterbom and Mossman (1978), indicating that our semi-permeable suit holds no advantage over impermeable suits by this measure.

Most studies of the temperature effects of protective suits have used subjects performing physical exercise with or without the addition of high ambient temperatures (Goldman, 1963; Joy and Goldman, 1968; de V. Martin and Goldman, 1972; Avellini, 1983; Smolander, Louhevaara, Tuomi, Korhonen and Jaakkola 1984; Thorton, Brown and Redman 1985). Such protocols would be expected to produce more body temperature elevation than our non-exercise protocol. A case of heat stroke (Cole, 1983) and some lesser heat related injuries (Carter and Cammermeyer, 1985) have been attributed to the effects of MOPP gear similar to the variety tested in the present study. However, these occurred during outdoor training exercises involving exertion. The heat stroke occurred under environmental conditions of 80^{o}F, with 84% humidity.

Goldman's (1963) study of resting subjects wearing protective ensembles in various environments (see Heart Rate section, above, for details), found that subjects did not reach a rectal temperature of 39.5^{o}C (the actual temperatures achieved were not given). Atterbom and Mossman (1978), studying an impervious suit, found no change in rectal temperature in a brief (15 minute) observation of subjects at rest. It is not surprising that 12 hours in MOPP gear would produce more core temperature elevation than 15 minutes. Our MOPP results agree with Goldman (1963) in that none of our subjects were near their 39.5^{o}C core temperature cutoff.

Previous studies have found decreased exercise endurance while wearing a protective suit (Atterbom and Mossman, 1978; Avellini, 1983). Smolander et al. (1984) found reduced isometric muscle endurance in subjects wearing impermeable gas protective clothing. McGinnis, Bensel and Lockhart, (1973) found improved performance on a torque test when protective gloves were worn. This test required subjects to apply angular force to a 0.75 inch diameter brass cylinder grasped with one hand. It was presumed to be a measure of the ability to hold onto objects. The torque test is somewhat analogous to our grip strength measure. However, there was an immediate and

persistent decrement in grip strength when the MOPP gear, including similar gloves, was worn. It may be that use of our dynamometer involves more dexterity than grasping a cylinder. Previous studies have reported decreased dexterity with similar gloves (Johnson and Sleeper, 1986; McGinnis et al., 1973). However, U. S. chemical defense gloves have been found to allow more dexterity than U. K. or Canadian gloves (Vittorio and Cattroll, 1975).

Previous studies have found that increased body temperature either from exercise (Horne and Staff, 1983) or from a hot bath (Horne and Reid, 1985) increases the proportion of slow wave sleep. Our finding of a significant correlation between the increase in core temperature and SLEEPINESS when the MOPP gear was worn may be a psychological analog to this physiological relationship.

Mask vs MOPP Effects

The comparisons between the data from the Mask study and the first 4 hours of the MOPP study demonstrated that the full MOPP gear had significantly greater effects than the M17A2 mask alone and that these larger effects were not dependent on the longer (12 hour) exposure. This may indicate that the other portions of the protective gear have independent detrimental effects. Alternatively, the masks and other parts of the gear may have interactive effects.

Sessions Effects

It is not surprising that subjects in the Mask study (both conditions) reported more fatigue symptoms as the day went on and subjects in the MOPP study had a decrease in POMS Vigor and an increase in SAM Fatigue, Negative Mood, and Sleepiness over time. The tasks involved were not very interesting, and there probably was a boredom factor. The linear decreases in heart rates in both studies may have resulted from the almost no physical activity during testing, with the subjects gradually approaching their resting heart rate. The post lunch increase seen in the MOPP study (see Fig. 5) is probably related to food ingestion triggering increased blood

delivery to the gastrointestinal system. Also, subjects were often up moving around during the lunch break. The lunch-break introduced changes unrelated to the wearing of MOPP gear in almost all variables.

The trend analysis across sessions on these variables did not indicate any adaptation to wearing MOPP gear over time. The trends observed were the same in the no MOPP and MOPP conditions. There were no condition by session interactions. This indicates that the initial negative effects of the gear did not increase greatly as it was worn for longer periods of time. The normal circadian drop in temperature over the day may have occurred only in the No MOPP subjects (with a slight pre-post lunch break increase), while MOPP subjects showed a more constant core temperature throughout the 12 hrs. Presumably an increase in heat storage from the suit was being balanced by the circadian drop, and if the suit were worn during a period of circadian elevation in temperature, there might have been an amplification of that elevation.

Correlates

It was hypothesized that there would be a negative correlation between negative psychological changes with the gear and the amount of previous experience with that gear. However, the present data suggest that simply using the gear may not be sufficient to reduce or eliminate the negative psychological responses. Tharion et al. (1986) observed that subjects performing field tests in MOPP gear reported less respiratory distress, mental fatigue, muscle exhaustion, and general fatigue if they received special training in coping strategies and were given the opportunity to eat. It was not reported if the coping strategies alone made a difference.

Male vs Female

Hamilton and Zapata (1983) reported that the U. S. aircrew chemical defense ensemble had more negative effects on the mood of females than males. Their male subjects actually showed less mood deterioration after 6 hours in the chemical defense gear than after the same time period in a standard flight suit. Their female subjects showed a greater mood decrement

in the suit. Those results may be confounded somewhat by the fact that the female subjects were exposed to higher environmental temperatures than the males. Also, the changes were not statistically significant.

There were no female subjects in the MOPP study. In the Mask study, females showed a statistically greater increment in heart rate when the mask was worn. MANOVA revealed no other male-female interactive effects in the changes seen in the mask condition. So, this is minimal evidence of a sex difference in sensitivity to mask effects. It is unfortunate that female subjects were not available for the MOPP gear study where the overall greater effects might have allowed us to confirm or refute such a difference.

CONCLUSION

Wearing the M17A2 mask while performing sedentary activities over a four hour period was found to increase symptom reporting. An increase in heart rate was only seen in the female subjects. Wearing full MOPP gear for 12 hours while performing the same tasks caused more and greater physiological and psychological effects. None of these changes were of a degree to indicate that this gear would seriously compromise the performance of soldiers who wear it during non-exertional activities.

REFERENCES

Atterbom, H. A. and Mossman, P.B. (1978) Physiological effects on work performance of vapor-barrier clothing and full-face respirator. Journal of Occupational Medicine 20:45-52.

Avellini, B.A. (1983) Physiological evaluation of chemical protective clothing (Technical Report No. 151). Natick, MA: Navy Clothing and Textile Research Facility.

Brooks, R.R., Xenakis, S.N., Ebner, D.G., and Balson P.M. (1983) Psychological reactions during chemical warfare training. Military Medicine 148: 232-235.

Carter, B.J. and Cammermeyer, M. (May 1985) Biopsychological responses of medical unit personnel wearing chemical defense ensemble in a simulated chemical warfare environment. Military Medicine 150:239-249.

Carter, B.J. and Cammermeyer, M. (December 1985) Emergence of real casualties during simulated chemical warfare training under high heat conditions. Military Medicine 150.657-663.

Cole, R.D. (1983) Heat stroke during training with nuclear, biological, and chemical protective clothing: case report. Military Medicine 148:624-625.

Craig, F.N., Blevins, W.V., and Cummings, E.G. (1970) Exhausting work limited by external resistance and inhalation of carbon dioxide. Journal of Applied Physiology 29:847-51.

Craig, F.N., Blevins, W.V., and Froehlich, H.L. (1971) Training to improve endurance in exhausting work of men wearing protective masks: a review and some preliminary experiments (Technical Report No. 4535). MD: Edgewood Arsenal.

de V. Martin, H. and Goldman, R.F. (1972) Comparison of physical, biophysical, and physiological methods of evaluating the thermal stress associated with wearing protective clothing. Ergonomics 15:337-342.

Dukes-Dobos, R.J. and Smith, R. (1984) Effects of respirators under heat/work conditions. American Industrial Hygiene Association Journal 45:399-404.

Flook, V. and Kelman, G.R. (1973) Submaximal exercise with increased inspiratory resistance to breathing. Journal of Applied Physiology 35:379-384.

Gee, J.B.L., Burton, G., Vassallo, C., and Gregg, J. (1968) Effects of external airway obstruction on work capacity and pulmonary gas exchange. American Review of Respiratory Disease 98:1003-1012.

Goldman, R.F. (1963) Tolerance time for work in the heat when wearing CBR protective clothing. Military Medicine 128:776-786.

Hamilton, B.E. and Zapata, L. (1983) Psychological measurements during the wear of the US aircrew chemical defense ensemble (USAARL Report No. 83-7). Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory.

Harber, P., Tamimie, R.J., Bhattacharya, A., and Barber, M. (1982) Physiologic effects of respirator dead space and resistance loading. Journal of Occupational Medicine 24:681-684.

Harber, P., Tamimie, J., Emory, J., Bhattacharya, A., and Barber, A. (1984) Effects of exercise using industrial respirators. American Industrial Hygiene Association Journal 45:603-609.

Harris, R.J. (1976) Primer of Multivariate Statistics. NY: Academic Press, pp. 96-106.

Hermansen, L., Vokac, Z., and Lereim, P. (1972) Respiratory and circulatory response to added air flow resistance during exercise. Ergonomics 15:15-24.

Horne, J.A. and Staff, L.H.E. (1983) Exercise and sleep: Body heating effects. Sleep, 6, 36-46.

Horne, J.A. and Reid, A.J. (1985) Night-time sleep EEG changes following body heating in a warm bath. Electroencephalography and Clinical Neurophysiology, 60, 154-157.

Johnson, R.F. and Sleeper, L.A. (1986) Effects of chemical protective handwear and headgear on manual dexterity. In Proceedings of the Human Factors Society 30th Annual Meeting (pp. 994-997). Santa Monica, CA: Human Factors Society.

Joy, R.J.T. and Goldman, R.F. (1968) A method of relating physiology and military performance. A study of some effects of vapor barrier clothing in a hot climate. Military Medicine 133:458-470.

Kelly, T.L., Yeager, J.E., Sucec, A.A., Englund, C.E., and Smith D.A. (1987) The effect of the M17A2 gas mask on spirometry values in healthy subjects. (Technical Report No. 87-39). San Diego, CA: Naval Health Research Center.

Lerman, Y., Shefer, A., Epstein, Y., and Keren, G. (1983) External inspiratory resistance of protective respiratory devices: effects on physical performance and respiratory function. American Journal of Industrial Medicine 4:733-740.

Louhevaara, V., Tuomi, T., Korhonen, O., and Jaakkola, J. (1984) Cardiorespiratory Effects of respiratory protective devices during exercise in well-trained men. European Journal of Applied Physiology 52:340-345.

McGinnis, J.M., Bensel, C.K., and Lockhart, J.M. (1973) Dexterity afforded by CP Protective gloves (Technical Report No. 73-35-PR). Natick, MA: U.S. Army Natick Laboratories.

Morgan, W.P. (1983) Psychological problems associated with the wearing of industrial respirators: A review. American Industrial Hygiene Association Journal 44:671-676.

Naitoh, P., Englund, C.E., and Ryman, D.H. (1983) Extending human performance during sustained operations through sleep management (Technical Report No. 83-13). San Diego, CA: Naval Health Research Center.

Naitoh, P., Englund, C.E., Ryman, D.H. (1984) Restorative power of naps in designing continuous work schedules. Journal of Human Ergology, Suppl. 34: 259-278.

Norusis, J. (1985) SPSS-X Advanced Statistics Guide. McGraw Hill, N.Y..

Rauch, T.M., Banderet, L.E., Tharion, W.J., Munro, I., Lussier, A.R., and Shukitt, B. (1986) Factors influencing the sustained performance capabilities of 155mm howitzer sections in simulated conventional and chemical warfare environments (Technical Report No. T11/86). Natick, MA: U.S. Army Research Institute of Environmental Medicine.

Ryman, D.H., Englund, C.E., Kelly, T.L., and Naitoh, P. (1987) Mood, symptom, fatigue, sleepiness and vital sign changes in mask and protective suit under non-exercising conditions. In Proceedings of the Sixth Medical Chemical Defense Bioscience Review (pp 669-72). MD: U.S. Army Medical Research Institute of Chemical Defense.

Ryman, D.H., Naitoh, P., and Englund, C.E. (1984) Minicomputer tasks in the study of effects of sustained work on human performance. Behavioral Research Methods, Instruments and Computers 16:256-261.

Shephard, R.J. (1962) Ergonomics of the respirator, pages 51-56 in Davies, C.N. (ed.) Design and Use of Respirators, New York, NY: MacMillan Co.

Smolander, J., Louhevaara, V., Tuomi, T., Korhonen, O., and Jaakkola, J. (1984) Reduction of isometric muscle endurance after wearing impermeable gas protective clothing. European Journal of Applied Physiology 53:76-80.

Spioch, F.M., Kobza, R., and Rump, S. (1962) The effects of respirators on the physiological reactions to physical effort. Acta Physiologica Polonica 13:637-649.

Stemler, F.W. and Craig, F.N. (1977) Effects of respiratory equipment on endurance in hard work. Journal of Applied Physiology: Respiratory, Environmental, and Exercise Physiology 42:28-32.

Tharion, W.J., Rauch, T.M., Munro, I., Lussier, A.R., Banderet, L.E., and Shukitt, B. (1986) Psychological factors which limit the endurance capabilities of armor crews operating in a simulated NBC environment (Technical Report No. T14/86). Natick, MA: U.S. Army Research Institute of Environmental Medicine.

Thorton, M.B., Brown, G.A., and Redman, P.J. (1985) The effect of the UK aircrew chemical defence assembly on thermal strain. Aviation, Space, and Environmental Medicine 56:208-211.

Van Huss, W.D., Hartman, F., Craig, F.N., and Steinhaus, A.H. (1967) Respiratory burden of the field protective mask under exercise load (Abstract). Federation Proceedings 26:721.

Vittorio, P.V. and Cattroll, S.W. (1975) Dexterity afforded by CW protective gloves (Technical Note No. 75-21). Canada: Research and Development Branch of the Department of Defence.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: Unclassified	1b. RESTRICTIVE MARKINGS: None
2a. SECURITY CLASSIFICATION AUTHORITY: N/A	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE: N/A	
4. PERFORMING ORGANIZATION REPORT NUMBER(S): NHRC Report No. 88-11	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION: Naval Health Research Center; 6b. OFFICE SYMBOL (If applicable): Code 60	7a. NAME OF MONITORING ORGANIZATION: Commander, Naval Medical Command
6c. ADDRESS (City, State, and ZIP Code): P.O. Box 85122, San Diego, CA 92138-9174	7b. ADDRESS (City, State, and ZIP Code): Department of the Navy, Washington, D.C. 20372
8a. NAME OF FUNDING/SPONSORING ORGANIZATION: Naval Medical Research & Development Command; 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code): Naval Medical Command National Capital Region, Bethesda, MD 20814-5044	10. SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. 63764; PROJECT NO. 2M46376 4B995; TASK NO. AB.087-6; WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
(U) PSYCHOLOGICAL AND PHYSIOLOGICAL EFFECTS OF WEARING A GAS MASK OR PROTECTIVE SUIT UNDER NON EXERCISING CONDITIONS

12. PERSONAL AUTHOR(S)
RYMAN, David H., KELLY, T.L., Englund, C.E., Naitoh, P., and Sinclair, M.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Interim	FROM ____ TO ____	1988 February 02	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Sustained operations; Gas mask; Chemical protective gear; Cognitive performance, Human factors engineering

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Comparisons of psychological and physiological measures of subjects in the M17A2 mask for 4 hrs vs not in mask (Study 1), and subjects in the MOPP4 chemical protective suit for 12 hrs vs subjects in regular fatigues (Study 2) were made. Minor fatigue-related symptoms and heart rate of female subjects increased significantly in the mask conditions in Study 1. In Study 2 significant increases in fatigue symptoms, negative mood and sleepiness, and decreases in vigor and positive mood were found in the suit condition. Heart rate and core temperature were significantly elevated while in the suit, and grip strength decreased. All these changes except for positive mood, were significant for the first four hours. The increased symptoms and sleepiness and decreased heart rate were significant in the first hour.

The changes observed, although significant, were not different from those observed previously over two sustained 20 hr days for non-exercising subjects (Naitoh, Englund, & Ryman, 1983, 1984). Both psychological and physiological changes in the MOPP suit were not to a degree to indicate that wearing this gear for 12 hrs without exercise would seriously impair cognitive performance. Keywords:

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION: Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL: David H. RYMAN	22b. TELEPHONE (Include Area Code): (619) 553-8375; 22c. OFFICE SYMBOL: 60

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE

U.S. Government Printing Office: 1985—